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Investigation on Water Recording system for Large User of Water Supply Network Based on PLC

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Abstract

The water consumption of large users in the water supply system is necessary in the performance of the modeling analyze of water supply network or water quality changing studies. There is a lack of reliable, low-cost method that is able to modify the usual mechanical water to an intelligent one. This research mainly describes a simply designed transformation from gear rotation to a practicable on/off pulse signal which is collected and storied by PLC as the terminal. All date can be read from the PLC by a computer after a sampling period, such as 10 days or less. The running results show that the recording system is reliability, stability, which provides a powerful data support for the modeling of water supply network and water consumption forecast of large users in demonstration area. This paper demonstrated sufficient measurement transformation technology. The basic design can also be adapted for other target ranges.

Keywords: PLC;water supply network;large users; Water meter

1. Introduction

As a core technology of modeling for urban water supply network, the water daily consumption of large users is particularly important. A major research in this paper is on the user's water consumption for each 15 minutes of recording time in accordance with a cycle 7 days test data, and obtained the changing character from it to support the modeling of water supply network in the demonstration researching area. There are about 30 large water users in this region, including schools, office buildings, hospitals and factory, etc. whose water meters are almost basically traditional mechanical type meters. Therefore, it is almost impossible to achieve the real-time data logging. Currently, many novel designs about modifying the mechanical meter to a electronic or intelligent instrument are presented, but most of them are used for remote data integrated database management system such as intelligent buildings, family, apartments or commercial buildings which are based on RIF smart IC card or wireless communication technology [1-4], but there is little application for the study of real-time testing.

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Because Programmable Logic Controller (PLC) can not only implement complex logic operations, but also complete a variety of sequence or timing of the closed-loop control functions, and also own advantages such as a small volume, flexible assembly, high anti-interference ability and reliability in harsh environments, long uninterrupted run and so on. In this paper, investigations have been carried out to realize a real time large user's water consumption record system.

2. The Structure of Recording Syetem

The system consists of meter rotor sensor, PLC, electrical switches, power supply batteries and waterproof case composition, as shown in Figure 1. A special electronic signaling module has been settled on the common water meter rotor sensor. The electronic module can turn mechanical gear signals into pulse signal which would be transmitted to the PLC through signal wire. According to the pre-written programs, the PLC realizes the acquisition to pulse signals, data processing, storage, and other functions. Because the system has been installed in the water meter chamber well, a stable power supply is necessary. Two 12V12AH accumulators are be used in this design. Based on testing results, the system can run at least 20 days under the conditions of 10℃ temperature environments and 15 min sampling frequency. The experiments also presented lower temperature could accelerate the power consumption. For instant, two accumulators have run 12 days when the environment temperature falls to 0℃. In a word, two accumulators can guaranty at least one week continuous sampling operation without other power supply. Moreover, a computer can be connected with the PLC via RS485 converting USB module to export the logging date to the computer after a cycle of data acquisition, and then use the appropriate software to deal with the date. As a result of duty and humid in the water meter chamber well, the PLC and accumulator are encapsulated into an IP68 waterproof box and seal the gap by fluid sealant at last.

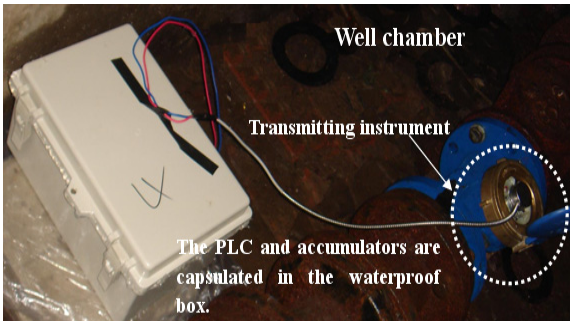

Figure 1. Water consumption recording system for large users in the wells

3. Sensor's Transformation

3.1Transformation Theory .

As the only measurement instruments for financial settlement between water supplying company and large users, the water meter plays an extremely important position in water statistics for large users. Currently the water meter of large users are mechanical forms instead of remote meter or intelligent ones, whose diameters are mostly DN50, DN100 and DN150 in JINAN demonstration area. According to the project planning, the large users' water meter should to be read every 15 minutes and last at least one

week. While mechanical water meter does not achieve that function, say nothing of storage or remote transmission. Thereby, the primary work should change water meter into intelligent instead of mechanical form. The working principle is as following: an electrode contact pad will be settled on the wheel in the liquid seal wheel box, and a sensor chip will be installed under the corresponding precision circuit board. When the wheel rotates, the electrode contact pad read the corresponding wheel rotation cycle number from the chip of the sensor. As a result, the rotation cycle number of the pointers in the mechanical water meter will be changed into pulse signal which can be transmitted to the PLC and complete the storage, acquisition and analyze. The connection principle is shown in Figure 2.

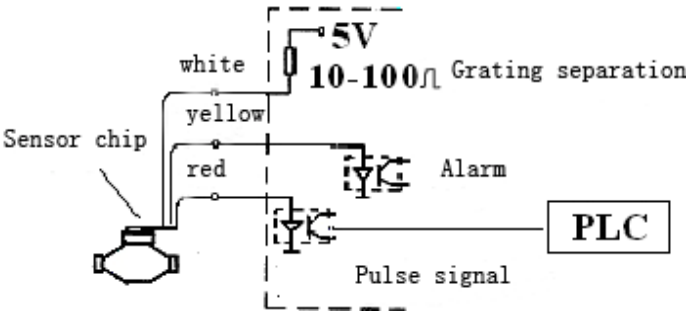

Figure 2. Wiring diagram of water system recorder

3.2Installation

The installation is as follows: First, open the water meter cover, the double-headed pointer inserted in the appropriate location. For example: require for assembled remote water meter each 10kg of water sending a pulse signal, So pointer position should be installed in × 0.001; and then put sensors in the right place in accordance with the order shown in Figure 3, access holes at the double-headed pointer and tighten the cover. Should pay attention to the distance between the top of a needle and bottom of the glass meter distance should be 0.3 to 1 mm, glass thickness not exceeding 6 mm, while sensor access hole in the water meter just above the needle, the error does not exceed ± 5mm, Canada is not allowed between the gaskets, water meter if the meter sensor cover along with the rotation, not easy to locate, you can use the two washers to locate accurately.

Once installed it would be shown as Figure 4, the water meter will be connected to the water pipes or be blown with wind , as long as the double-headed pointer rotate flexibly, If the distance is too short, water meter will cover Crimping double pointer. Replace the skin pad then to reinstall in accordance with step 2. Finally, the remote meter is connected to the multimeter by which the availability will be checked. That is to say, if the measured show the multimeter complete a switch with the double-headed pointer per revolution, the whole remote water meter is feasible.

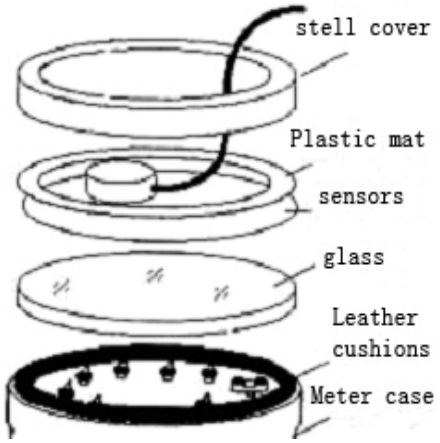

Figure 3. Sensor mounting structure

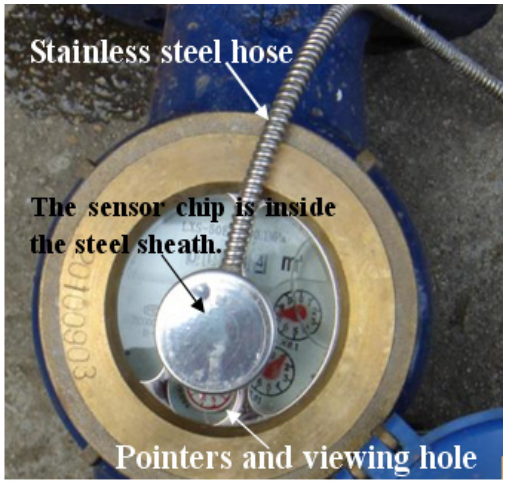

Figure 4. Water meter after transformation

3.3Calibration

According to the above analysis of modification process, it shows that this method turns the rotation of a pointer into the cutting circuit magnetic field movement by transmitting instrument. That is to say, one pulse will be gain after each cycle rotation of a point. It is present that the water meter data read from dial is still validity. Before application on the large user, each water meter was checked by the national center for water meter inspection to make sure that the logging water quality by recorded PLC is the same as the dial value by meter itself. The result proves that this method is feasible and accurate. The accumulation water volume in PLC is almost the same as the data on water meter dial basically with a

error less than 5 kilograms. Due to the skidding of pointers or the wrong setting position of viewing hole, those water meters which has higher error usually should be reinstall or further adjust.

4. Programming

In order to realize the function of storage, timing and sampling, it is necessary to compose a feasible program by computer, which will be written into the PLC at last [5]. The PLC will not work until be triggered. After a sampling period, all dates can also be exported conveniently from the PLC by a computer. The program design idea is as following: the set-time counter within PLC is 15 minutes. At this time, X1, the channel on the PLC, which connects the pulse sensor transmitted from water meter, collects signals a frequency of 100 and stores them in the temporary register where the pulses' number will be added up. After 15 minutes, the cumulative result will be sent into a power-down protection register whose order number star from D4000. The temporary register needs emptying and the next 15minute test happens. Meanwhile, the Power-down protection system can guarantee date storage at least 1 month under the condition of absence accumulators' power supply. The total date of one day is 96. After seven days' running, the PLC will stop working else an unknown error will happen by reason of the finite number of power-down protection registers. The major procedure in PLC is as following:

```
LDP      X0          * detecting X0 with the rising edge
OR         M0    *parallel connecting normal- open contacM0
ANI      X2          * series with normal closed contact X3
ANI      X3          * series with normal closed contact X3
OUT      M0          * coil driving M0
LD    M0   * operation began after normal open contact M0
OUT     Y0                    * coil driving Y0
LD   M0  * operation began after normal open contact M0
ANDP   X1       * detecting series X1 with the rising edge
OUT     C0       K10000       * constant driving coil CO constant 10,000
LD    M0        * operation began after normal open contact  M0
OUT     T0       K9000        *Timing-driven coil T0 ; constant 10,000
LD   T0        * operation began after normal open contact T0 (the turn-on after 900s)
MOV    CD0      D4000 [D4999]
 *the first date is stored in D4000 and the n second test data is stored in the D(4000+n) register
INC  D4999      * the value in the 4999th register unit plus 1
OUT      M1           * coil drive M1
LDP      M1           * detecting M0 with the rising edge
RST      C0           * clear counters C0
RST      T0           * clear timers T0
LDP      X3          * rising edge detection X3
OR     M777      * parallel connecting normal open contact M777
OR     M777     * parallel connecting normal open contact M777
ZRST   D4000 D4999       *clear data register D4000-D4999
```

5. Test Results

5.1Analyze

Figure 5 has been drawn by records to a hospital for 3 consecutive days, from which the change regularity is obviously and water consumption laws are consistent everyday. Basically, it starts to increase

from morning and reaches top by noon. Then, it begins to decrease from one o'clock. Meanwhile the highest water quantity is less than 45 m^3/h and more than 5 m^3/h. we can conclude the rule of our customer basing on the water consumption of recordings and analysis for a week which provides a strong theoretical basis for demonstration in water supply network modeling.

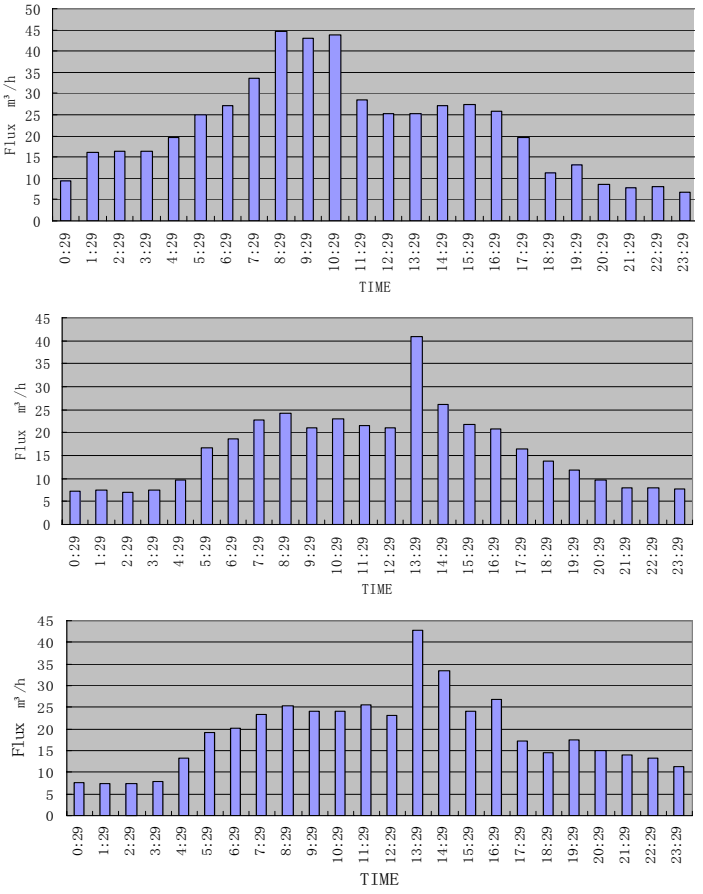

Figure 5. Consecutive Days Water Consumption of a Hospital

5.2Terminal End

The PLC itself has a strong anti-jamming and high reliability. The Software program uses the digital filter, the communication calibration measurement and further accumulation to improve the system anti-jamming. As a result, the system can complete the data records successfully in some pump room or transformer substation which have large power consumptions and lead to a higher electrical field noise. In addition, it provides an open platform for the information measure of those large users to use PLC as terminals. For example, we can increase some parameter measurement equipments such as water quality inspection sensors, flow or pressure measurement sensors, which can realize the storage of data easily by connecting with PLC through the communication cables.

5.3Communication

In the later study, in order to realize data acquisition , records synchronously and remote sending for 20 large users , the DTU（Data Transmit Unit）has been adopted instead of the PLC to realize the receiving of pulse signal which is transmitted by intelligent water meters, and send those dates obtained from water meters to the terminal computer server via GPRS wireless communication network. This method is aiming at the characters those who have many targets and distribute remotely and dispersion .At the same, time continuity and real-time is demand higher. While, for the application of DTU, the cost will increase in early equipment investment and operation.

6. Conclusion

In this paper, it mainly introduces an entire process with a kind of mechanical water meter modification which can transform the rotation information into pulse signal and realizing the data acquisition and processing, storage and transmission by PLC as terminal equipment. The whole system has many advantages such as lower cost, higher accuracy and reliability and strong anti-interference. On the other side, it provides a great open platform for the subsequent measurement such as water quality, pressure and flux. The system has finished the testing of tens large customers where the PLC gives full play to system of real-time data automatic monitoring record function. As a whole, they works is in good conditions with stable operation, low fault rate and high data reliability. Test results provide powerful data supporting for water consumption forecast of large users in demonstration area. Furthermore, this paper demonstrated sufficient measurement transformation technology. The basic design can also be adapted for other target ranges.

Acknowledgment

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